Worksheet: Balancing, mole:mole ratios, mass-mass, mass-mole, mass-molecule problems

1. For the following:
a. Balance the equation
b. State the mole mole ratios
c. State the mass in grams of each substance

a. $P_4 + O_2 \longrightarrow P_4O_6$

b. $Fe(OH)_3 + HCl \longrightarrow FeCl_3 + H_2O$

2. Phosphorus trichloride (PCl_3) is made when white phosphorus (P_4) reacts with chlorine gas: $P_4 + Cl_2 \longrightarrow PCl_3$

a. Balance the equation
b. How many grams of phosphorus are required to produce 5.49 g PCl_3?

3. How many moles of oxygen are required to prepare 142 g P_4O_{10} from elemental white phosphorus?

a. Balance the equation
b. Calculate moles of oxygen.
c. What mass of oxygen is needed for this reaction to occur?

4. Suppose 2.17 g HgO is thermally decomposed to elemental mercury and oxygen.

a. Balance the equation
b. What mass of mercury will be produced?
c. How many oxygen molecules will be produced?

5. How many grams of Cu_2O could be produced from 9.90 g CuCl reacting with H_2S gas? (Hint: This is a double replacement reaction).

a. Balance the equation
b. Find grams of Cu_2S

Worksheet: Mass-Mass Problems

1. How many grams of hydrogen can be produced from the reaction of 11.5 g of sodium with an excess of water? (0.505 g H_2)

2. An excess of nitrogen reacts with 2.0 g of hydrogen. How many grams of ammonia are produced? (11.2 g NH_3)

3. How many grams of oxygen are required to burn completely 85.6 grams of carbon? (228 g O_2)

4. In problem 3, how many grams of CO_2 will be formed? (314 g CO_2)

5. In the decomposition of potassium chlorate, 64.2 grams of oxygen are formed. How many grams of potassium chloride are produced? (99.7 g KCl)

6. The action of carbon monoxide on iron(III) oxide can be represented by the equation:

$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$. What would be the minimum amount of carbon monoxide used if 18.7 g of iron were produced? (14.1 g CO)

7. How many grams of hydrochloric acid are required to react completely with 75.1 grams of calcium hydroxide? (74.0 g HCl)

8. How many grams of hydrogen are produced when 5.62 grams of aluminum reacts with excess hydrochloric acid? (0.631 g H_2).

Worksheet: Graham's law, mass-volume, and volume-volume

1. What is the ratio of the speed of hydrogen molecules to that of oxygen molecules when both gases are at the same temperature? Remember that both elements are diatomic. (3.98:1)

2. At a certain temperature, the velocity of oxygen molecules is 0.076 m/s. What is the velocity of helium atoms at the same temperature? (0.215 m/s)

3. What volume of hydrogen at STP can be produced from the reaction of 6.54 grams of zinc with hydrochloric acid? (single replacement rxn) (2.24 L)

4. How many grams of sodium chloride can be produced by the reaction of 112 ml of chlorine at STP with excess sodium? (composition rxn) (0.585 g)

5. An excess of hydrogen reacts with 14 grams of nitrogen. How many liters of ammonia will be produced at STP? (composition rxn) (22.4 L)

6. How many liters of oxygen are required to burn 1.00 liter of methane, CH_4? (combustion rxn) (2 L)

7. How many liters of carbon dioxide will be produced by burning completely 5.00 liters of ethane, C_2H_6? (combustion rxn) (10 L)

8. What volume of oxygen is required to burn completely 401 ml of butane, C_4H_{10}? (combustion rxn) (2.61 L)

Ideal Gas Law

1. What temperature must be maintained to ensure that an 8.3 L flask containing 0.5 mole of a certain gas will show a continuous pressure of 220 kPa. (439.47 K)

2. At 12°C and 140 kPa, 0.05 moles of a gas has a mass of 1.98 g.
   a. Calculate the volume of the gas. (0.8458 L or dm^3)

   b. Calculate the gases formula mass(Recall: formula mass=grams/mol) (39.6g/mol)

3. What volume must be maintained to ensure that 2.1 atm of a 0.75 mole gas at -10°C is stable? (7.71 L or dm^3)

4. What temperature must be maintained to ensure that a 6 .8 dm^3 flask containing 0.25 mole of a certain gas will show a continuous pressure of 80 kPa? (261.85 K)

5. What would be the volume of 28 g CH_4 at standard pressure and temperature? Note: you will need to change grams to moles. (38.97 L)

Mass-Mass, Mass-Volume &Volume-Volume Practice

1. How many grams of NaCl will be produced when 22.85 g of HCl are neutralized by an excess of NaOH?

2. What volume of hydrogen gas is produced when 135 grams of aluminum are completely reacted with excess sulfuric acid at STP?

3. How many grams of magnesium oxide are produced when 10.00 grams of magnesium burn in an excess of oxygen?

4. How many liters of ammonia gas are produced when 35 grams of liquid nitrogen completely react with excess hydrogen at STP?

5. How many grams of aluminum would react completely with 17.50 grams of copper (II) chloride?

6. What volume of bromine gas is produced if 75.2L of chlorine react with excess hydrogen bromide at STP?

Worksheet: Everything!!!

1. A compound was known to be either $CuCl_2$ or $CuBr_2$. A 5.00 g sample yielded 2.36 g of copper. What was the compound?

2. Calculate the formula of a compound, given that 55.85 g of iron combines with 32.06 g of sulfur.

3. How much iron could be obtained from 1 ton of iron ore containing 45% Fe_2O_3? (Put your answer in pounds of Fe)

4. How much SO_2 could be obtained from burning 25 g sulfur in oxygen? (Put your answer in moles of SO_2)

5. What would be the mass of the residue if 8.375 g of $U(SO_4)_2 \cdot 9H_2O$ were heated until the water had evaporated?

6. The element M forms the chloride MCl_2. This chloride contains 75% chlorine. Calculate the atomic mass of M.

7. How many tons of Fe_2O_3 will contain 12 tons of Fe?

8. A compound is either $ZnBr_2$ or ZnI_2. An 8.00 g sample yielded 1.64 g of zinc. What is the compound?

9. How many pounds of KCl will be formed if 50 pounds of $KClO_3$ are decomposed by heating?

10. It was found that 10.0 g of a pure compound contains 3.65 g K, 3.33 g of Cl, and 3.02 g of O. Calculate the empirical formula of the compound. Its molecular mass is 106.55. What is its molecular formula?

Answers:

1. $CuCl_2$
2. FeS
3. 629.29 lbs.
4. 0.78 moles
5. 6.082 g
6. 23.65 g
7. 17.16 tons
8. ZnI_2
9. 30.4 lbs.
10. $KClO_2$, $KClO_2$

Harder Mass-Mass Problems

1. How many grams of air are required to complete the combustion of 93 g of phosphorus to diphosphorus pentaoxide assuming the air to be 23% oxygen by mass. (520 g air)

2. How many metric tons of carbon dioxide can be produced from the combustion of 1.00 metric ton (1000kg) of coke that is 90% carbon? (3.3 metric tons CO_2)

3. What mass of a sample that is 98% sulfur would be required in the production of 75 kg of H_2SO_4 by the following reaction sequence: (~25.0 kg)

$S_8 + 8O_2 \longrightarrow 8SO_2$
$2SO_2 + O_2 \longrightarrow 2SO_3$
$SO_3 + H_2O \longrightarrow H_2SO_4$

4. How many pounds of 58% pure salt cake (Na_2SO_4) could be produced from150 lbs of 85% pure salt.
$2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$

Percent and Theoretical Yield

5. A student was preparing copper metal by the reaction of 1.274 g of copper(II) sulfate with zinc metal. She isolated a yield of 0.392 g of copper. What was her theoretical and percent yield? (0.5072 g, 77.3%)

6. A sample of lime, CaO weighing 69 g was prepared by heating 131 g of limestone. What was the % yield of the reaction? (94%)

Harder Mass-Mass Problems

1. Calculate the number of pounds of lime(CaO) that can be prepared by heating 200 lbs. of limestone that is 95% pure $CaCO_3$.

2. Commercial sodium hydrosulfite is 90% pure $Na_2S_2O_4$. How many tons of the commercial product could be made by using 100 tons of zinc? The reactions follow:

$Zn + 2SO_2 \longrightarrow ZnS_2O_4$

$ZnS_2O_4 + Na_2CO_3 \longrightarrow ZnCO_3 + Na_2S_2O_4$

3. $Bi + 4HNO_3 + 3H_2O \longrightarrow Bid(NO_3)_3 \cdot 5H_2O + NO$

a. How many grams of $Bi(NO_3)_3 \cdot 5H_2O$ would be formed from a solution of 10.4 grams of bismuth in nitric acid?

b. How many grams of 30% nitric acid(containing 30% HNO_3 by mass) is required to react with this mass of bismuth?

4. $2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$

How many pounds of 83.4% pure salt cake (Na_2SO_4) could be produced from 250 lbs. of 94.5% pure salt?

Helpful conversions:
453.6 g=1 lb
2000 lbs=1 ton

Worksheet: Limiting Reactants

1. If 6.57g iron reacts with 10.7 g HCl, then H_2 and iron(II) chloride are produced. Determine whic reactant is in excess and by how much and determine the mass of each product.

2. When 8.76 g Al reacts with 29.37 g HCl, then aluminum chloride and hydrogen are produced. Which reactant is in excess and by how much. Calculate the mass of each product.

Worksheet: Limiting Reactants

1. 24 g of ammonia(NH_3) reacts with 35 g of hydrogen chloride in a composition reaction forming ammonium chloride. How much ammonium chloride is formed? If any reactant remains unreacted, how much is left over?

2. 13 g of CH_4 is burned in 50 g of oxygen. How many grams of CO_2 and H_2O are produced? Which reactant is left over and by how much?

3. 196 g of sulfuric acid(H_2SO_4) reacts with 316 g of calcium acetate in a double replacement reaction. How many grams of each product is produced? If any reacctants remain unreacted, which one is it and how much is left?

Lab: Iron-Copper(II)chloride Reaction
Copper(II)sulfate

In this lab, we will react the metal iron with a solution of copper(II) chloride or copper(II)sulfate and a single replacement reaction will take place. The purpose of this lab is to determine which type of iron chloride(iron sulfate) is formed in the process(ferrous or ferric).

Procedure:
1. With a China marker, label a 250 ml beaker with you and your partners initials for identification. Now mass the empty, clean, dry 250 ml beaker on the balance to the nearest 0.01g.
2. Set the balance to read 3 grams heavier than the beaker if using $CuCl_2$ and 3.5 grams heavier than the beaker if using $CuSO_4$. Add the crystals onto a piece of weighing paper. Even though the crystals are in excess, you do need to know the precise amount of crystal massed. This is necessary for the calculation section.
3. Add about 50 ml of distilled water to the crystals in the beaker. Stir the mixture until all the crystals are dissolved.
4. Obtain 2 nails. Mass the nails together and record their mass to the nearest 0.01g
5. Place the nails in the copper solution and let the system stand for about 30 minutes if done in one class period or overnight if two class periods. You should tilt the beaker and lean it on something so the nails are in the solution. They should not, however, be completely submerged.
6. Pick up the nails, one at a time and wash off the reddish-brown material from the nails into the beaker. You may want to use a scoopula to scrape off some of the solid. Wash the nails with distilled water after you are done.
7. Dry the nails and measure their mass and record.
8. Carefully decant the solution from the reddish-brown material remaining in the beaker. Leave as much of the reddish-brown material in the beaker as possible. Your teacher will show you how to do this.
9. Wash the remaining solid in the beaker with about 25 ml of distilled water and decant. Repeat the washing process about 3 times.
10. After the final washing, the solid must be dried. This will be done overnight under the hood. When you get the beaker back the next day, measure the mass.

Questions:
1. Write and balance the equation for both possible reactions.
2. Using the mass of the iron that reacted and the mass of the copper product, determine the moles of each and then the mole:mole ratio between Fe:Cu.
3. Using the result from #2, which equation represents the reaction that occurred in your experiment?
4. What type of reaction occurred? comp, decomp, single, or double?
5. Using the limiting reactant(Fe nails), calculate the mass of crystals that actually reacted. (Do a mass-mass problem). How much excess crystals were initially put in the beaker? Show the calculation.
6. State 3 possible lab errors that could have occurred.
7. Calculate the theoretical yield of Cu and the percent yield of Cu.

I. Title: Iron-Copper(II)Chloride Reaction
Iron-Copper(II)Sulfate Reaction

II. Purpose: use complete sentences

III. Data: Get it Signed!!!! (seperate data sheet)
Beaker (Before and After with dried Cu)
Cu crystals before rxn
2 Fe nails(before and after)
dried Cu(after)

IV. Analysis
1. If Fe +2:

___Fe + $CuCl_2$ / $CuSO_4$ ⟶ _____ + _____ (balance it also!)

If Fe +3:

___Fe + $CuCl_2$ / $CuSO_4$ ⟶ _____ + _____(balance it also!)

2. Change g to moles
(Before Fe-after Fe) g x $\frac{1 \text{ mole Fe}}{\text{P.T. g Fe}}$ = _____mole Fe

(dried Cu) g x $\frac{1 \text{ mole Cu}}{\text{P.T. g Cu}}$ = _____mole Cu

Now divide by the smallest moles to get the mole: mole ratio between Fe:Cu

3. If you have a 1:1 ratio, Fe +2 Make sure you can explain why
If you have a 2:3 ratio(1:1.5), Fe+3 Make sure you can explain why

4.comp, decomp, single, double? Explain.

5.(Before-after) g Fe x $\frac{1 \text{ mole Fe}}{\text{P.T. g Fe}}$ x $\frac{\text{? mole } CuCl_2(CuSO_4)}{\text{? mole Fe}}$ x $\frac{\text{P.T. g } CuCl_2(CuSO_4)}{1 \text{ mole } CuCl_2(CuSO_4)}$ =

=_____g $CuCl_2(CuSO_4)$ that actually reacted.

How much was in excess?
(initial g copper crystals)- (amount of copper crystals that actually reacted(above)) =_____g crystals in excess

6. List 3 possible lab errors.

V. Conclusion(three paragraphs)
a. Summarize procedure
b. Tell me what you learned
c. How do you know you accomplished the purpose?

Name:

Data Table: Iron- Copper(II) chloride reaction
Iron-Copper(II) sulfate reaction

Get it Signed!!!!!

Mass Of:	BEFORE	AFTER
250 ml beaker	g	with reddish-brown dried Cu g
Cu crystals ($CuCl_2$ or $CuSO_4$)	g	XXXXXX
2 iron nails	g	g
reddish-brown dried Cu	XXXXXX	g

Caluculations for Iron-Copper (II) chloride/Iron-Copper (II) sulfate Lab;

Mass Of	Before	After
250 ml beaker	103.06 g	103.86 g
Cu Crystals ($CuSO_4$)	3.51 g	xxxxxxx
2 iron nails	14.59 g	13.87 g
Reddish-brown dried Cu	xxxxxxx	0.80 g

Change grams to moles:

a. $\frac{\text{(Before Fe – After Fe) g}}{1} \times \frac{\text{1 mole Fe}}{\text{P.T. g Fe}} =$ _____ moles Fe

$\frac{\text{.72 g Fe}}{1} \times \frac{\text{1 mole Fe}}{\text{55.85 g Fe}} =$ **.0129** moles Fe

b. $\frac{\text{(dried Cu) g}}{1} \times \frac{\text{1 mole Cu}}{\text{P.T. g Cu}} =$ _____ moles Cu

$\frac{\text{.80 g Cu}}{1} \times \frac{\text{1 mole Cu}}{\text{63.55 g Cu}} =$ **.0126** moles Cu

Mole:Mole Ratio:

$\frac{.0129}{.0126} = 1.02$ ∴ 1 : 1 ratio which means that you were given Fe +2 because of the mole to mole ratio from the balanced equations

How much $CuSO_4$ actually reacted:

$\frac{\text{(Before – After) g Fe}}{1} \times \frac{\text{1 mole Fe}}{\text{P.T. g Fe}} \times \frac{\text{? mole } CuSO_4}{\text{? mole Fe}} \times \frac{\text{P.T. g } CuSO_4}{\text{1 mole } CuSO_4} =$ _____ g $CuSO_4$

$\frac{\text{.72 g Fe}}{1} \times \frac{\text{1 mole Fe}}{\text{55.85 g Fe}} \times \frac{\text{1 mole } CuSO_4}{\text{1 mole Fe}} \times \frac{\text{159.62 g } CuSO_4}{\text{1 mole } CuSO_4} =$ **2.06 g CuSO4**

How much $CuSO_4$ was in excess:

(initial g copper crystals) – (amount of copper crystals that actually reacted) = _____ g

3.51 g – 2.06 g = **1.45 g**

Theoretical yield (how much Cu should have been formed):

$$\frac{\text{g Fe}}{1} \times \frac{1 \text{ mole Fe}}{\text{P.T. g Fe}} \times \frac{? \text{ mole Cu}}{? \text{ mole Fe}} \times \frac{\text{P.T. g Cu}}{1 \text{ mole Cu}} = \_\_\_\_\_ \text{ g Cu}$$

$$\frac{.72 \text{ g Fe}}{1} \times \frac{1 \text{ mole Fe}}{55.85 \text{ g Fe}} \times \frac{1 \text{ mole Cu}}{1 \text{ mole Fe}} \times \frac{63.55 \text{ g Cu}}{1 \text{ mole Cu}} = \mathbf{.82 \text{ g Cu}}$$

Percent yield (what percent of what was supposed to be formed was formed):

$$\frac{\text{After g Cu}}{\text{T.Y. g Cu}} \times 100 = \_\_\_\_\_ \%$$

$$\frac{.80 \text{ g}}{.82 \text{ g}} \times 100 = \mathbf{97.6 \%}$$

Mass Of:	BEFORE	AFTER
250 ml beaker	g	with reddish-brown dried Cu g
Cu crystals ($CuCl_2$ or $CuSO_4$)	g	XXXXXX
2 iron nails	g	g
reddish-brown dried Cu	XXXXXX	g

Mass Of:	BEFORE	AFTER
250 ml beaker	g	with reddish-brown dried Cu g
Cu crystals ($CuCl_2$ or $CuSO_4$)	g	XXXXXX
2 iron nails	g	g
reddish-brown dried Cu	XXXXXX	g

Mass Of:	BEFORE	AFTER
250 ml beaker	g	with reddish-brown dried Cu g
Cu crystals ($CuCl_2$ or $CuSO_4$)	g	XXXXXX
2 iron nails	g	g
reddish-brown dried Cu	XXXXXX	g